Volume 33 July, 1947 *Number 7*

Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Metals Grinding

Machinery Lubrication

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LUBRICATION

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Metals Grinding Machinery Lubrication

GRINDING, honing, lapping and super-finishing of machine parts serves to smooth down those microscopic high spots which would otherwise require flattening in service at the expense of power consumption, loss of productive efficiency and the imposing of an undue load on the lubricant used.

Grinding of metallic surfaces is brought about by contact at high speeds with some extremely hard material of more or less abrasive nature.

Speed is Most Essential

In consequence the modern grinding machine is designed for extremely high peripheral speed of the abrasive wheel. Due to this speed and the potential possibility of an appreciable temperature rise at all points of minimum clearance in the bearings where the lubricating films will normally be under considerable pressure, grinding machine lubrication must be carefully studied. An insufficient oil film at any such points might readily lead to impaired lubrication, subsequent wear of the contact surfaces, reduced production and ultimately the need for certain parts replacement.

REMARKABLE progress has been made during recent years in the perfection of precision mechanisms. Surface finish is an important adjunct to the operation of such mechanisms. The grinding machine, therefore, became a most necessary device, for surface finish of machine parts is obtained by grinding.

The process of grinding does what "run-in" used to be expected to do – and in far less time. This means that modern machinery can be brought up to speed sooner, to assure of the desired return on the investment without the loss of time which accompanies any operation which must be carried out at reduced speed.

Effective lubrication of the grinding machine spindle and the other parts contributes materially to coordination of speed and precision with the development of precision.

Speed Dictates Viscosity

As higher speeds are encountered, the procedure of lubricating by means of more fluid or lighter viscosity lubricants is generally followed in order to reduce drag, loss of power and to prevent increase in film temperatures due to internal friction between the component molecules of the lubricant. As a matter of interest, however, it is well to note that grinding machines for special service are also designed for grease lubrication, particularly where ball bearings are involved.

It is general practice to vary the viscosity or lubricant body inversely with the speed. In other words, for high speed conditions a comparatively light bodied lubricant can be used. Lower speeds (for the same load conditions) will require a heavier product. The reason for this is that the higher the speed the greater the degree to which the lubricant will be drawn into the clearance spaces by hydraulic pumping action. Where speeds are low and loads are more severe a still heavier lubricant may be required.

The rate of shear between the component molecules which make up the lubricating film is of

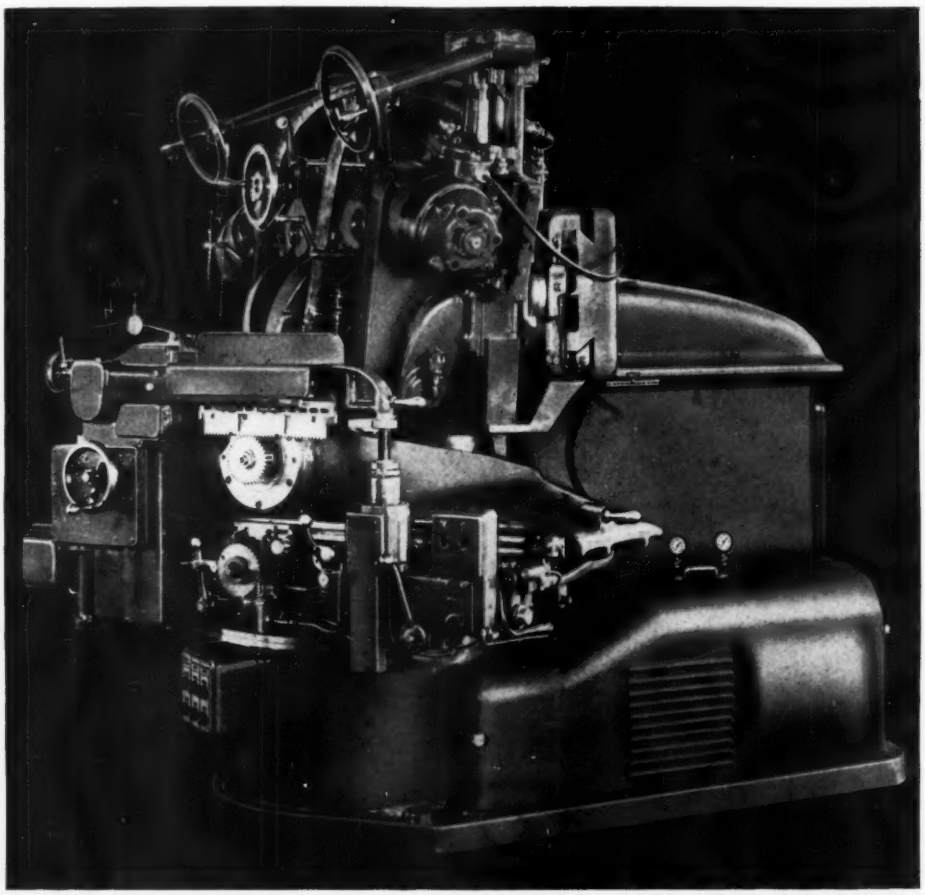
importance as it is increased with increase in speed — conversely, it is decreased with decrease in viscosity. So, while the rotating shaft develops greater pumping action and a lubricating film of more uniform thickness as the center of the shaft approaches the center of the bearing, the increase in shear will result in an increase in internal friction within the lubricant itself, unless the body or viscosity of the latter is reduced accordingly.

The nature or smoothness of the contact surfaces is also a factor. When running steel-on-steel as in the ball or roller bearing, research has proved that the more highly finished the surfaces, the more dependably can low viscosity oils be used in a properly sealed bearing housing. In the sleeve-type bearing, however, the steel shaft should not be too highly finished, as microscopic depressions should still exist to serve as reservoirs for lubricant. Again, to refer to research, it has been found that from 5 to 10 micro-inches thickness of lubricating film are advisable for higher peripheral speeds.

The development of a constant film of lubricant within a bearing clearance space, however, will be contingent upon the extent to which automatic lubrication is maintained. If oil is delivered by means of a drip feed oiler, wherein the principle is to supply just enough oil to maintain lubrication, increase in speed may cause impaired lubrication unless the rate of drip of oil is increased.

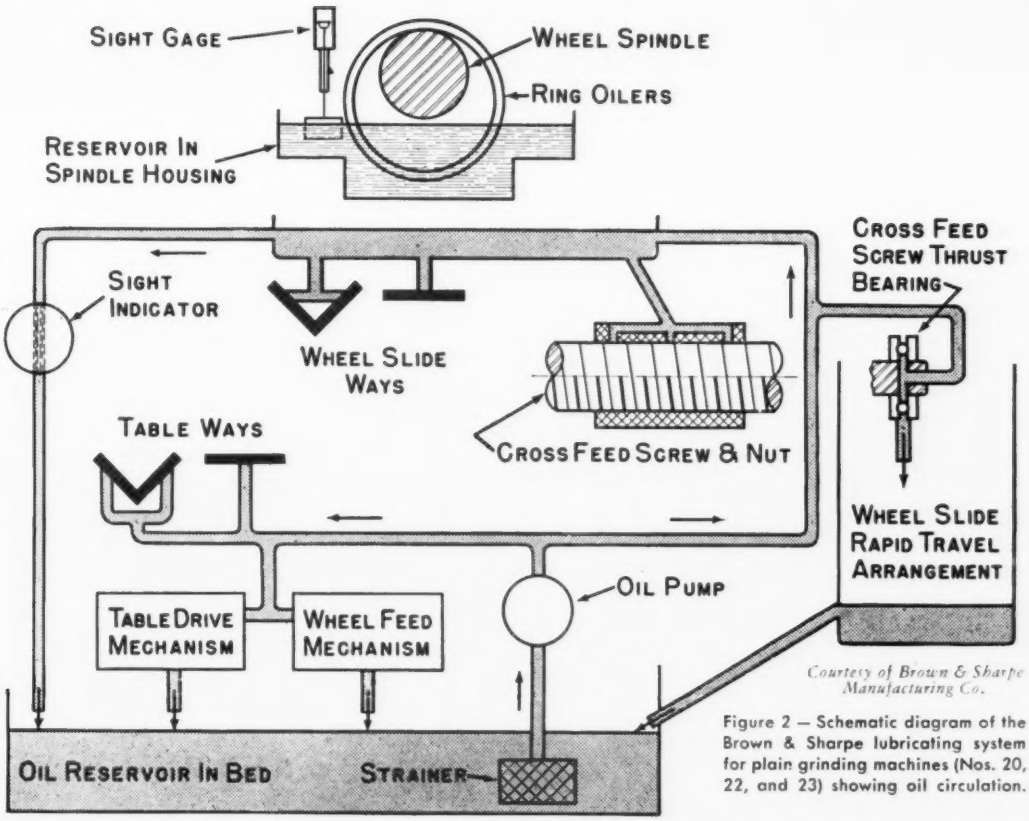
Where automatic lubrication of the force feed type is involved, there will often be more oil delivered than is required to maintain lubrication, i.e., flood lubrication, which will offset the effects of pressure. This is definitely advantageous in some grinding machines, where flood lubrication of the spindle has been proved to be an adjunct to positive development of speeds as high as 50,000 R.P.M. Other builders have utilized mist lubrication under similar operating conditions when even higher speeds are involved.

Flood lubrication also is beneficial in that the excess oil passing through the bearings will remove



Courtesy of Pratt & Whitney Division Niles-Bement-Pond Company

Figure 1 — Right front view of the Pratt & Whitney 10-inch 2-wheel hydraulic gear grinder.



Courtesy of Brown & Sharpe Manufacturing Co.

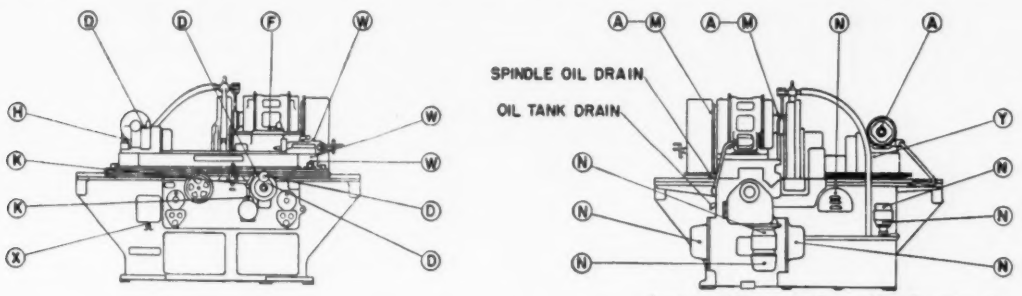
Figure 2 — Schematic diagram of the Brown & Sharpe lubricating system for plain grinding machines (Nos. 20, 22, and 23) showing oil circulation.

a certain amount of the heat developed during operation, or received from an external source.

To sum up, high speeds lead to the development of a more positive lubricating film, due to the increased hydraulic action or the extent to which the oil is drawn into bearing clearances. It also makes possible the use of a lighter spindle oil which will often reduce the amount of power consumed as well as the amount of internal friction developed within the oil itself.

When Using Grease

Grease is also applicable to high speed grinding machinery. When a bearing is properly designed to retain the lubricant, and a grease chosen which has a high degree of protective ability, it will insure



Courtesy of Brown & Sharpe Manufacturing Co.

Figure 3 — Lubrication chart for Brown and Sharpe (Nos. 20, 22 and 23) plain grinding machines. In brief it suggests:

A and Y — Clean and grease yearly using good ball bearing grease.
D — Oil daily with 300 SSU at 100°F. Machine Oil.
F — Fill when necessary with extra light high grade spindle oil. (See builders instructions).
H — Oil monthly with 300 viscosity machine oil.
K — Grease weekly with water repellent grease.
M — Oil monthly (sleeve-bearing motor).
N — Permanently sealed bearings.
W — Oil weekly with 300 viscosity machine oil.
X — Keep filled to gage with suitable high quality 300 viscosity table way oil.

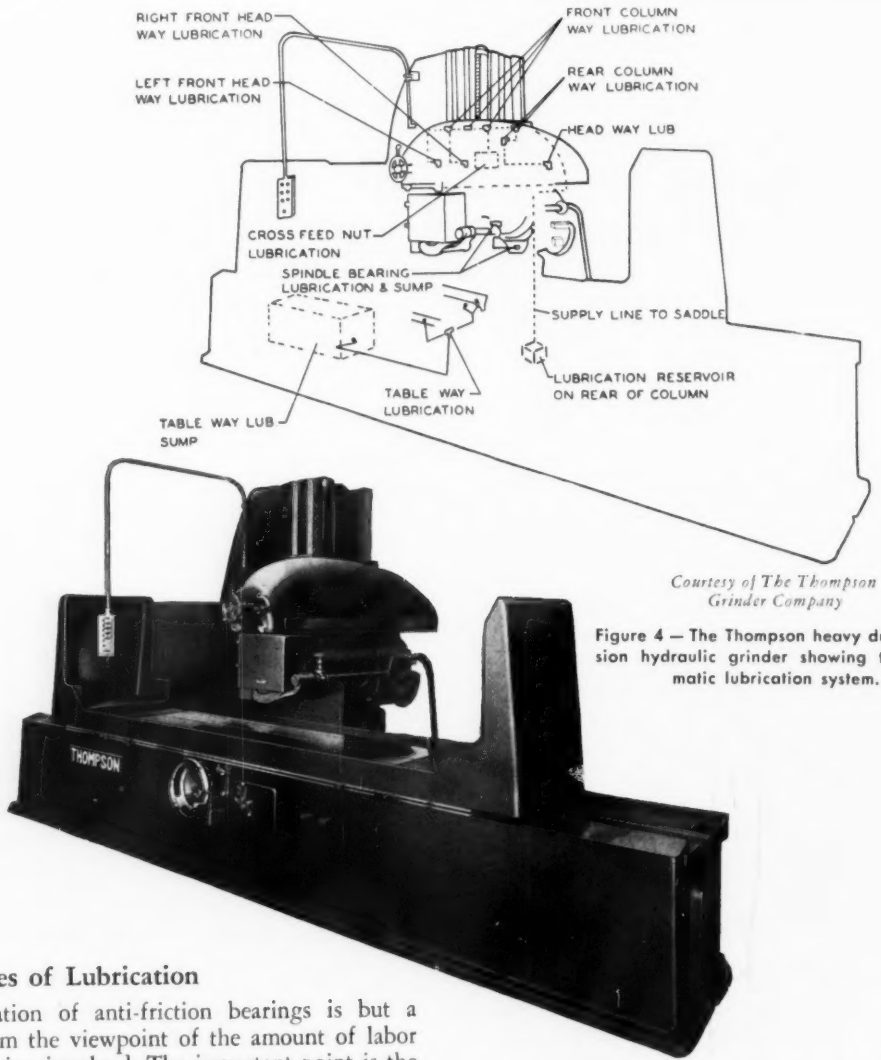
lubrication for an extensive period of operation, with the necessity for renewal perhaps only three to four times a year. Some ball bearings are designed and sealed so that the initial charge of grease lasts indefinitely.

Any such bearing in service should never be completely filled with lubricant, for this may not only lead to overheating or channelling of the product, but also to increased power consumption, due to the drag which may be imposed upon the rolling elements.

all the surfaces (which are highly finished) must be in as perfect condition as practicable. The lubricant must, therefore, serve the dual purpose of lubricating and protecting these surfaces against rusting, corrosion, pitting, or abnormal wear.

OPERATING CONDITIONS OF THE GRINDING MACHINE

The speed at which the modern grinding machine will operate depends upon the type of work to be performed, the amount of stock to be removed by grinding, and the nature of the materials involved. By virtue of these speed requirements and the accuracy demanded, the utmost care and attention has been devoted to design and construction of driving mechanisms, wheel spindles, feed screws and wheel slide ways.



Courtesy of The Thompson Grinder Company

Figure 4 — The Thompson heavy duty precision hydraulic grinder showing the automatic lubrication system.

Principles of Lubrication

Lubrication of anti-friction bearings is but a detail from the viewpoint of the amount of labor and attention involved. The important point is the original selection of the lubricant to be used, and the consideration of its characteristics as required by the principles of anti-friction bearing construction and operation.

In such bearings the purpose of lubrication is to facilitate as easy rolling as possible. To enable this,

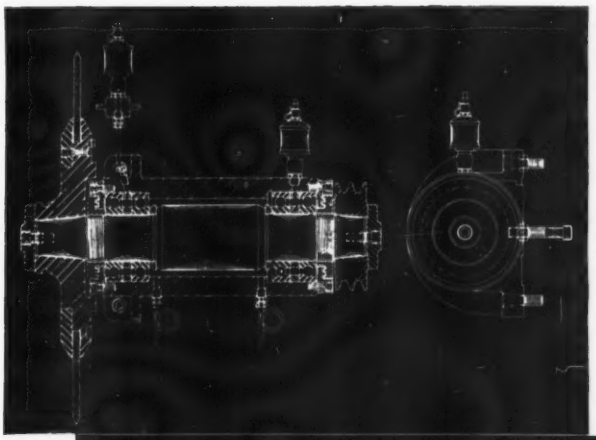
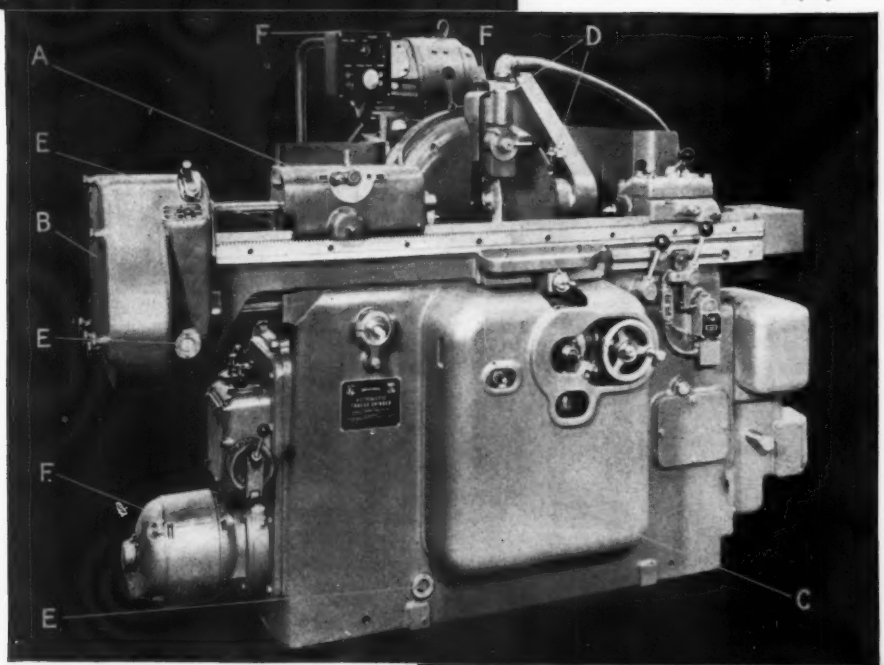


Figure 5 — (Center) Lubrication chart for a Jones & Lamson automatic thread grinding machine. "A" — is the headstock and "B" the change gear housing, both of which require a high grade heavy-medium machine oil. The Spindle oilers "D" require a high quality 150 SSU viscosity (at 100°F.) spindle oil; "E" indicates sight gages which should be checked daily. "F" are motor bearings, check monthly.

(Top Left) Assembly of 20" wheel spindle, ball bearing mounted.

(Bottom Right) Assembly of 24" wheel spindle, ball bearing mounted.

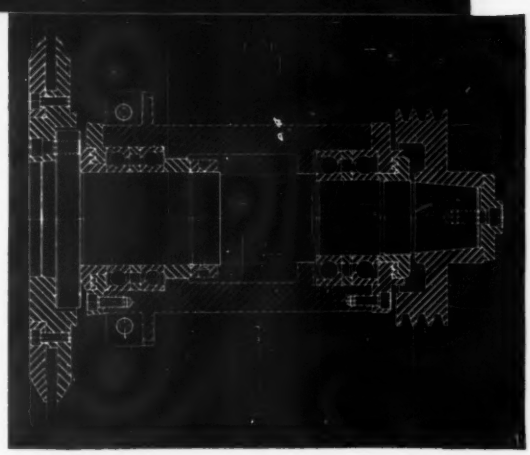
Courtesy of Jones & Lamson Machine Company



Accuracy and rigidity are features of the grinding machine when it is first put into service. They are the result of the cooperative efforts of the machine designer and tool builder. The continued maintenance of this accuracy and rigidity, however, is a problem for the operating engineer and lubricating specialist, for lubrication is decidedly essential in effective grinding and the ability to produce the maximum of results with the minimum of power requirement.

THE MAIN DRIVE

The grinding machine spindle is driven by belt connection or an electric motor. The latter permits of good flexibility in machine opera-



tion, reduces vibration and often enables very economical transmission of power. In machines of the latest type the motor is mounted directly on the wheel slide and belt-connected to the wheel spindle. In such design the motor armature virtually becomes the main shaft. Other recent designs utilize an extended armature shaft on the spindle to carry the wheel.

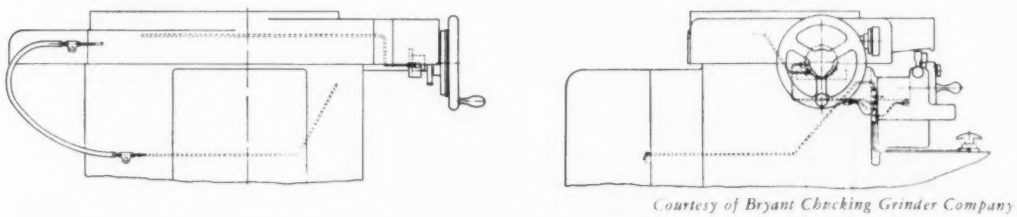
The idler and main drive shaft are very important elements in such machinery. They have, therefore, received careful study relative to the adaptability of the ball or roller bearing as a means of insuring most effective operation. The main drive shaft is, in fact, the salient factor in the maintenance of effective operation of the wheel spindle. On the other hand, this spindle is regarded as the most important member from the viewpoint of lubrication by virtue of its size, the heavy duty to which it is subjected, and the high speeds which frequently prevail.

Clearance Relates to Type of Lubricant

Low clearance is an aid to proper functioning of such bearings; the occurrence of any play between the component parts would tend to set up a certain amount of pounding which would be detrimental to effective operation. In ball bearings all motion must be as nearly akin to perfect rolling as possible. Light bodied lubricants should be used wherever they can be successfully retained in such a bearing, commensurate with the temperatures and pressures involved. In the oil sealed type of bearing the oil viscosity can vary from 40 to 200 seconds Saybolt Universal at 100 degrees Fahr.

THE GRINDING MACHINE SPINDLE

Where the grinding machine wheel spindle is built with plain or so-called sleeve-type bearings, the sight feed oil cup has been proven to afford the requisite degree of lubrication on some bearings especially where a wooden oil distributor is properly located within the bearing housing below the spindle. The three-part bearing is extensively used on certain of such machines, viz., a half box is located at the bottom and to the rear of the spindle housing. The top construction consists of two adjustable bearing segments. By means of suitable thumb-screws these latter can be readily adjusted to meet lubrication and pressure requirements without the necessity for stopping the spindle. This



Courtesy of Bryant Chucking Grinder Company

Figure 6 — Details of the Bijur lubrication system on the workhead cross slide of a Bryant Chucking grinder.

Wherever there is a possibility of oil leakage, however, or under conditions of dust, dirt or dampness, it may be advisable to use a specially treated oil, or to use grease as the lubricant. Greases furnish better seals against the entry of dust, dirt and moisture, thereby serving to protect the polished surfaces of the bearing elements in a very satisfactory manner. Grease also can be retained more dependably in a non-oiltight housing; on the other hand, dirt or grit that finds its way into a grease lubricated bearing has no means of settling out; it will usually be held in suspension, being carried round and round with the bearing elements to exert a wearing effect.

permits normal adjustment to be made without interfering with production. Another type of design consists of three or five pivoted shoes with the compartment full of oil.

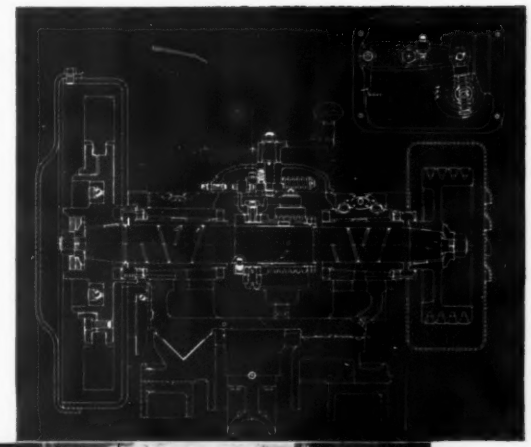
Flood Lubrication

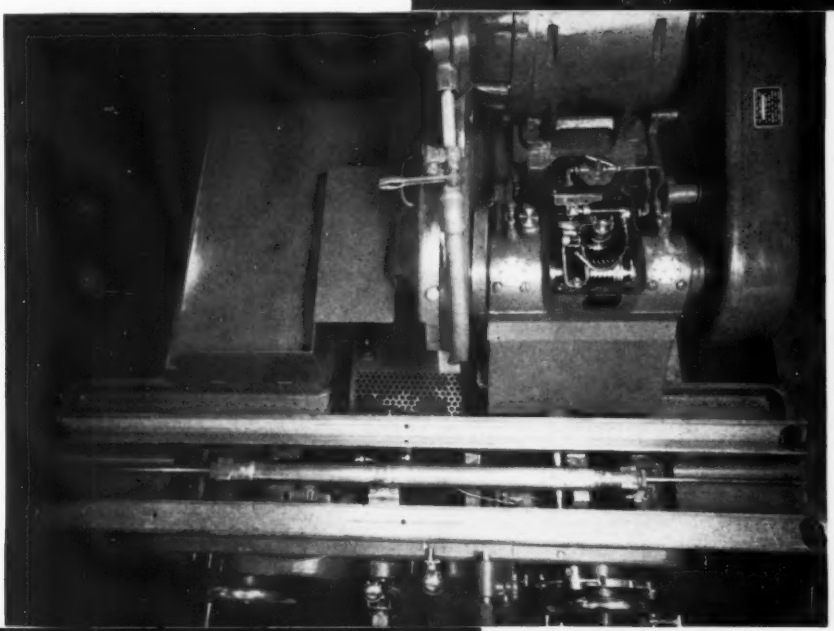
Flood lubrication has been developed to a marked degree, especially for the preservation of spindles. Mechanical or automatic circulation of the oil to the essential wearing parts can be admirably accomplished by means of a suitable chain-driven pump, or a pump which is driven directly from the wheel spindle. There must, of course, be adequate reservoir space with such a system to carry the

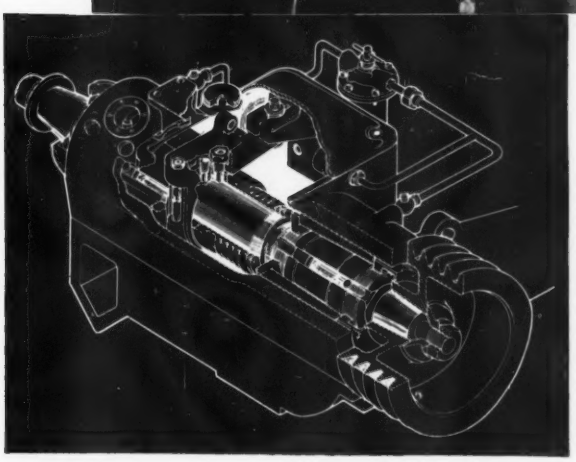
requisite volume of oil and provide for proper settling. In many machines the hollow wheel slide is used for this purpose; it also serves as a housing for the oil pump.

Cleanliness a Factor

Flood lubrication by means of oil circulation insures, perhaps, the greatest degree of operating cleanliness possible of attainment, for in addition to serving as a lubricant and coolant the oil will usually wash the entire system free of any accumulations of foreign matter. It is essential, however, that there be an ample quantity of oil in the system and sufficient volume in the reservoir to allow for precipitation or settling out of the majority of any foreign matter







Courtesy of Norton Company

Figure 7 — (Top) Section through a Norton Wheel Spindle and bearing.

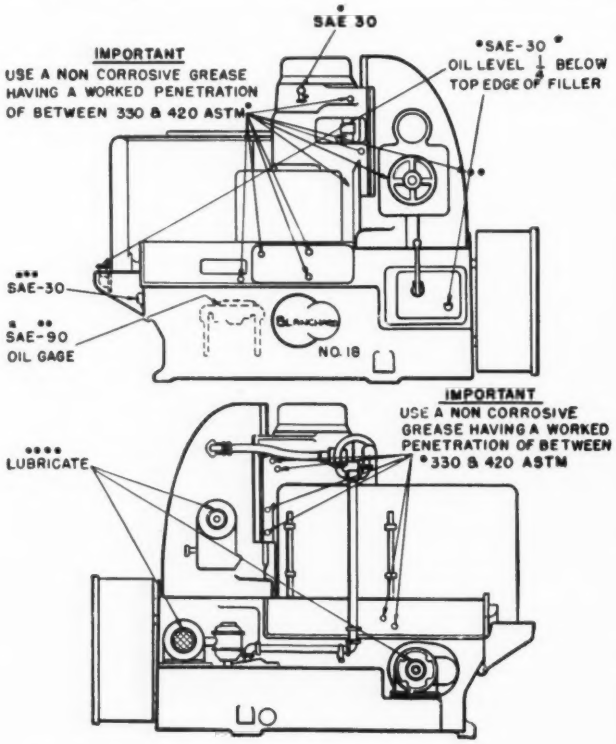
(Center) Wheel slide lubrication unit and reservoir, cover removed, and hydraulic cylinder and piping, table removed.

(Below) Details of the Norton wheel spindle. In the center of this design is a section indicated by solid white. In this area is set the spindle lubricating pump. This is placed in vertical position as the center photograph shows.

which may have been taken up during circulation; otherwise, its passage through the oiling system may cause serious scoring of bearings and shafting. More modern design provides for filtering the oil.

Minimum of Attention Required

The minimum of attention is required and normally but little adjustment is necessary in the operation of a flood lubricating system. Relative to adjustment, it is interesting to note that usually a suitable valve can be installed in the bearing cap or at some other accessible point to permit this. On grinding machines, where oil circulation adjustment is provided for in the bearing cap, an observation window or glass located in front of the bearing enables the operator to note the oil flow at all times.



Courtesy of The Blanchard Machine Company

Figure 8 — Showing the points of lubrication on a Blanchard grinder.

SELECTION OF LUBRICANTS

For Spindles

Normal conditions of grinding machine spindle operation will permit the use of a light to medium bodied straight mineral spindle or machine oil, the degree of refinement depending to a large extent upon the type of lubricating system.

In sight feed oilers, as used for spindle lubrication on many machines, an oil of from approximately 100 to 200 seconds Saybolt Universal viscosity at 100 degrees Fahr., will serve the purpose. Relative to the rate of oil feed, some authorities recommend adjustment of sight feed oilers to deliver from about 7 to 10 drops a minute.

It is practicable to use this same grade of oil for the spring-actuated wick-oiled bearing. In the ring oiling device, however, a somewhat heavier product will be necessary, the viscosity ranging from 200 to 300 seconds.

For Circulating Systems

Grinding machine bearings served by circulating systems can normally function on an oil of similar viscosity as mentioned for the spindle bearings. Re-usage of oil by circulation, however, imposes a very important requirement upon any oil for such service. In other words, it must readily separate from water or other foreign matter, and not tend to develop emulsions to any extensive degree; furthermore, it must be resistant to oxidation.

For this reason attention must be paid to the degree of refinement of any oil under consideration. That is, an oil should be used which has been so refined as to remove those hydrocarbon constituents which may lead to subsequent emulsification and oxidation, especially when the oil is agitated in the presence of air, and perhaps in contact with water or particles of metallic foreign matter. As a rule a viscosity range of from 40 to 300 seconds Saybolt Universal at 100 degrees Fahr., will meet requirements according to the design of the system and the speed of operation.

Oil Mist Lubrication

In the application of high speed ball bearings to grinding wheel spindle service where speeds as high as 100,000 rpm may be developed, a method of oil-mist lubrication has been perfected using very light viscosity spindle oils ranging from 40 to 150 secs. Saybolt Universal at 100 deg. F. The bearings on each end of the spindle develop a pumping action which causes the oil to circulate continuously around the spindle parts. External slingers effectively prevent entry of any outside dirt or liquid. By designing the bearing housing so that it will retain oil effectually, oil-mist lubrication has proved to be dependable, capable of protecting precision-finished ball bearings for lengthy

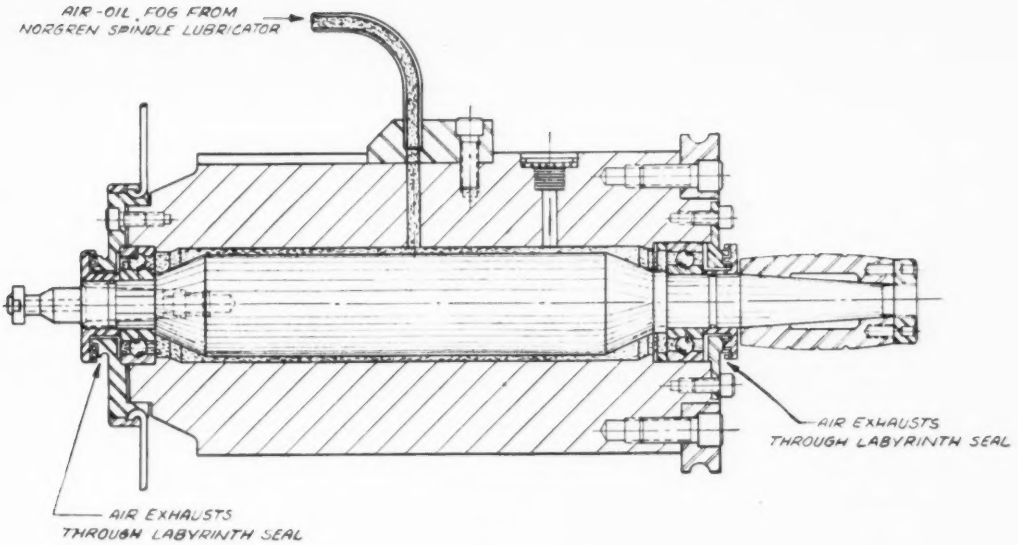
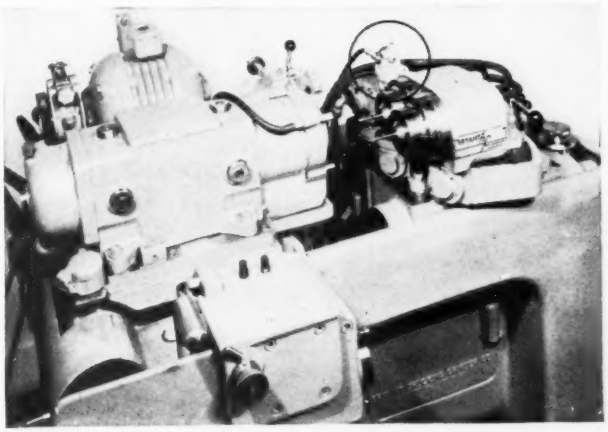


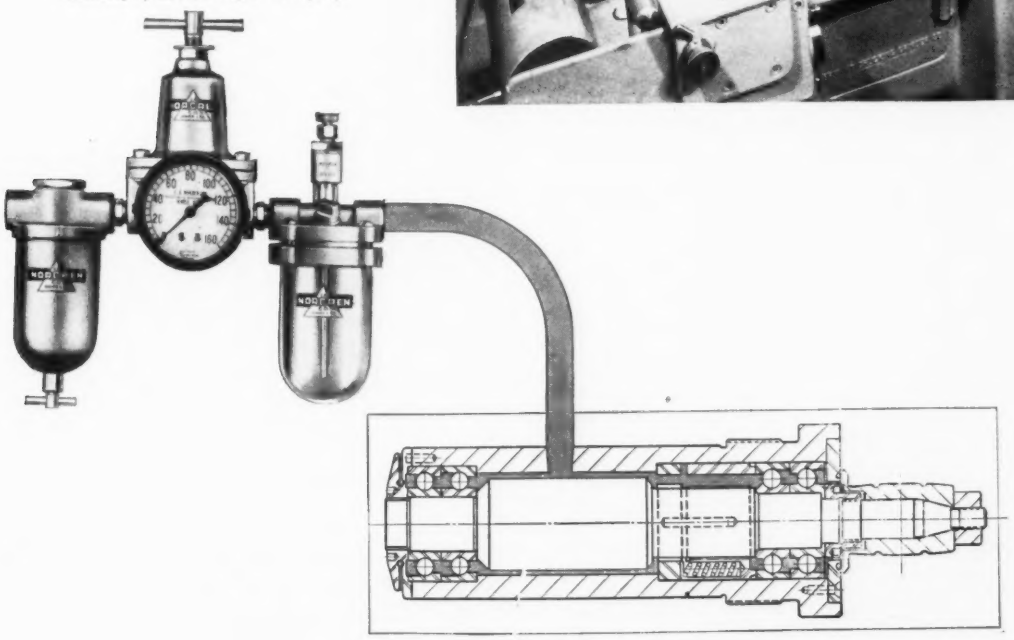
Figure 9 — (Top) Showing how the air-oil fog from a Norgren Spindle lubricator is distributed to maintain continuous lubrication.

(Center) Application of Norgren lubricating equipment to a Bryant Chucking grinder in some designs of which the twin hi-frequency wheel heads can be run up to 100,000 R.P.M.

(Below) The Norgren filter, regulator and lubricator, showing the tie-in to a high speed grinding spindle.

Courtesy of C. A. Norgren Company





periods, and keeping high speed grinding machines in continuous service. This is most important as much of this class of machinery is used today in the finishing of ball bearings for aircraft control mechanisms and the automotive industry. Air power as a means of developing an oil mist is also utilized on high speed spindle bearings, where the oil is fed drop by drop into a stream of low-pressure air which breaks up the oil into a fine mist.

Gear Shaft Bearings, etc.

For those other wearing elements in the average grinding machine, including reversing mechanisms with their essential gears, cams and bearings, an oil should be used which will meet the requirements of both hand and bath lubrication. This latter is prevalent in many reversing mechanism housings. The oil cup, however, prevails on the majority of the other general machine bearings.

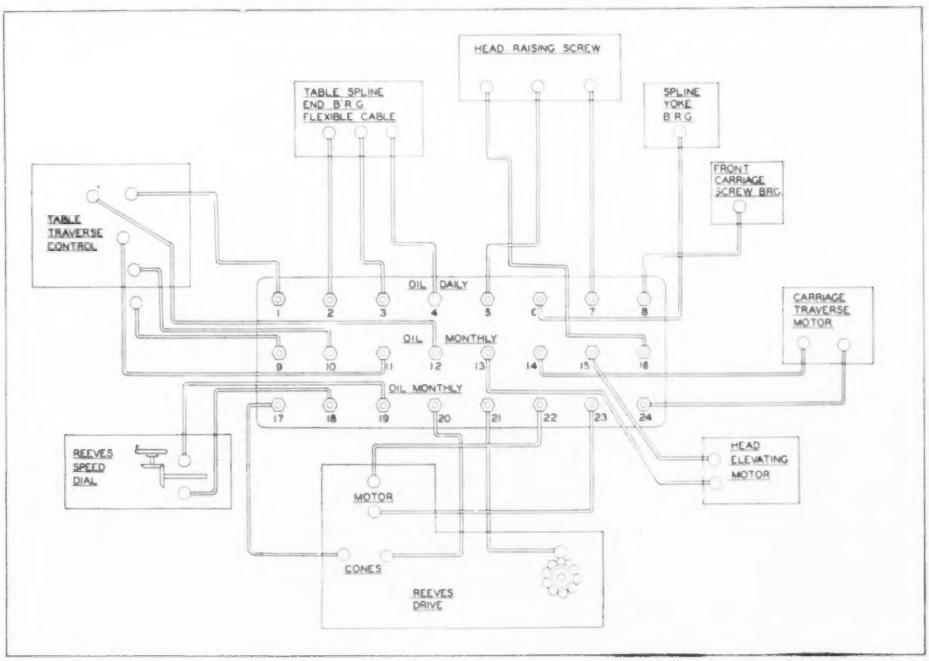
The duty is not severe. Therefore, a medium bodied straight mineral machine oil will, as a rule, serve the purpose satisfactorily, the viscosity range being from 200 to 400 seconds Saybolt at 100 degrees Fahr.

Flat Bearing Surfaces

There may, however, frequently be a problem in the lubrication of flat bearing surfaces such as V's and table ways, due to the varied pressures which may be developed. For this reason the utmost care should be paid to selection of the oil to be used, and the extent of viscosity or body required.

Lubrication of such surfaces can be accomplished by oil cups and suitable grooving of the ways, by application of the oil under pressure as in a force feed system or by the installation of rollers located in depressions which can be kept full of oil. These latter work automatically, for at each passage of the slide the respective rollers carry a film of oil up to the surfaces of contact, in much the same manner as a ring-oiler would lubricate a plain bearing. The modern force feed, filtering, oil circulating system is, however, regarded as most dependable.

The viscosity range to meet the pressure conditions of slide operation must of necessity be wide. Oftentimes, on smaller grinding machines it can be as low as 300 seconds Saybolt at 100 degrees Fahr. On the other hand, larger machines such as those designed for the grinding of steel mill rolls may require a lubricant as heavy in body as a steam cylinder oil, the actual viscosity being perhaps as high as 130 seconds Saybolt at 210 degrees Fahr. Oils which are fortified with oiliness agents are considered necessary for some types of way design.

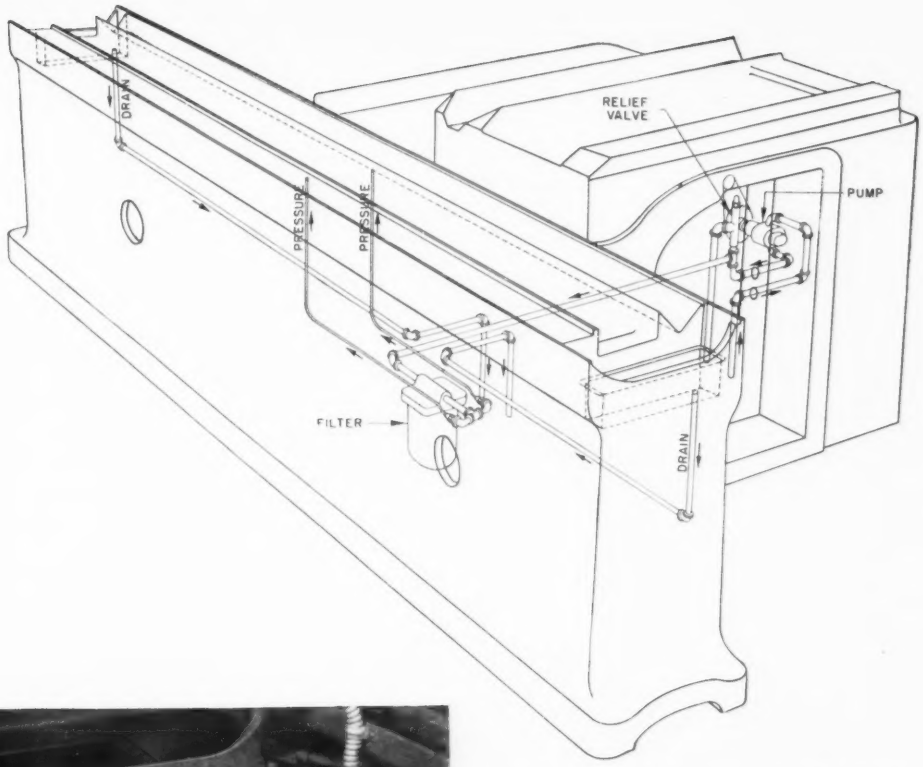


Courtesy of Hanchett Manufacturing Company

Figure 10 — Lubrication diagram for a Hanchett No. 36 rotary surface grinder.

Gears

High speed gears, and other motions, must be studied from the viewpoint of the extent to which centrifugal force will be developed and the lubri-



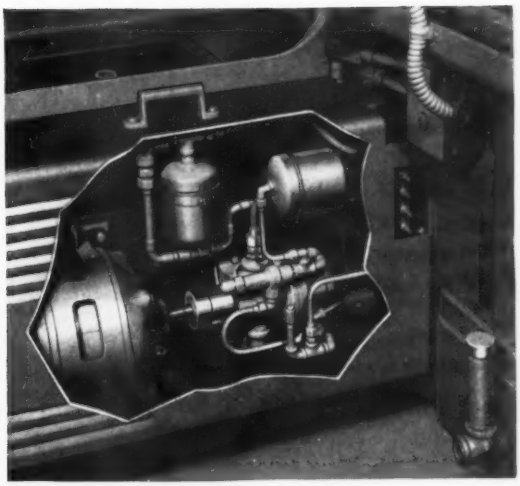
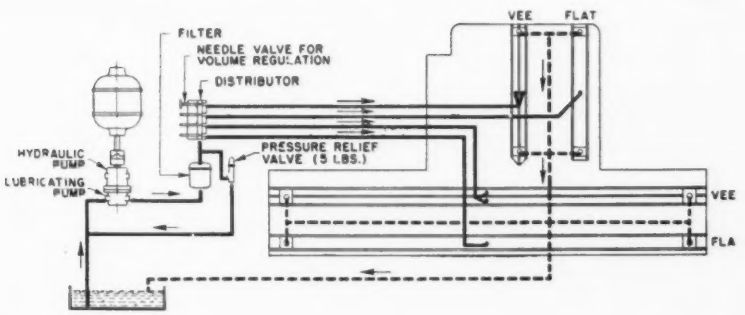


Figure 11 — (Top) The table ways oiling system on a Cincinnati grinding machine. This low pressure filtered oiling system assures an adequate supply of clean oil. Note piping layout.

(Center) Showing how the filters, relief valves, hydraulic pump and motor and lubricating pump are all housed together beneath the one cover where they can be easily serviced.

(Below) Circuit diagram for the automatic pressure lubrication of table ways and cross ways.

Courtesy of Cincinnati Milling and Grinding Machines, Inc.



cant thrown from the moving parts. Here there is more relationship between speed and the adhesive characteristics of the lubricant. This will be especially true on exposed gears. For this reason, the designing engineer should study the practicability of using proper housings. In an oil-tight gear housing a comparatively fluid oil can be used, especially if it is automatically delivered to the parts and not merely carried around the gear teeth to dip in the bath of lubricant.

FLUSHING AND CLEANING OF BEARINGS

Maximum protection of any grinding machine lubricant can be assured by keeping the lubricating system as free from foreign matter as is consistently possible, according to the operating conditions and bearing construction. There is always a possibility of entrance of impurities, especially where bearings may not be properly sealed. Continued churning of abrasive foreign matter with oil and its passage through plain bearing clearance spaces or in contact with highly polished balls and raceways will ultimately ruin any bearing.

Since it is not always possible to effect the requisite degree of sealing or to depend upon the seal being in good working order at all times, grinding machine bearing lubricating systems should be flushed and cleaned at periodic intervals. The frequency will depend upon the type of bearing, the type of seal, the lubricant used and the extent to which dust and dirt are present.

Systems served by sight feed oilers will in general require more frequent attention than ball bearings, due to the fact that their housings may be less carefully designed. Cleaning of drip-oiled plain bearings may be necessary or advisable at periods ranging from every two weeks to every several months. With ball or roller bearings once or twice a year is sufficient, unless operating conditions are especially dirty. Anti-friction bearings, however, are more delicate from the viewpoint of construction, and therefore the lubricant should not be allowed to become as contaminated as is permissable with other types of bearings.

Circulating oiling systems, in turn, possess natural advantages in that the flood of oil which is constantly passing through the bearings tends to wash out any grit, dirt, dust or metallic particles that may have gained entry. As a result, wear is reduced to a minimum just as long as the oil in the system does not become so highly contaminated as to be unable to precipitate such foreign matter during its period of so-called rest. For this reason the condition of the oil should be carefully watched and the system drained as soon as any excess of dirt becomes apparent in the reservoir or settling chamber.

The Lubricating Engineer

Lubricants for grinding, honing, lapping and super-finishing machinery used to be selected in a more or less haphazard manner, very often depending upon the experience of the oiler, and his ability to estimate pressures and note the extent to which wear might take place. Naturally his experience was limited. The plant lubricating engineer has brought about a decided change for the better in many plants. His experience covering a wide variety of operating conditions, and his familiarity with machine design, make his advice and service a valuable asset.

Lubricating engineering service provided by the oil industry, in turn, presents a number of valuable benefits to the operator of mass production machinery. Most pronounced is expert technical advice in the solution of lubrication problems, and application of methods of lubrication.

The experienced lubricating engineer also is conversant with lubricant characteristics and can often predict how some specific feature will be necessary to meet the operating conditions most economically and effectively.

Under the high speed conditions which prevail in the average grinding machine, knowledge of lubricant suitability is highly essential for the most efficient performance, for the modern grinding machine has passed beyond the stage of guess-work in regard to lubrication. One must be positive that lubricants are capable of affording maximum protection to all moving parts. As speeds increase very often boundary lubrication is approached.

CONCLUSION

Machinery which can reproduce its own accuracy of design and construction is indeed unique. It is doubly so where it is involved in mass production. This is the status of the grinding machine, as employed by productive industry in the manufacture of accurately designed machine parts. Subsequently, many of these parts must be lubricated. There is a direct tie-up between surface finish and lubrication. The better the finish the more assurance of positive lubrication provided the right lubricant is used. Effective grinding of metallic surfaces is necessary to obtain this finish.

The grinding machine itself must, of course, be in condition to function efficiently and at the designed speed to bring about this finish. This can only be assured by effective lubrication of its own operating parts. Realizing the high speed conditions which prevail and their effect upon temperature and oil film maintenance, petroleum research has made an intensive study of the relation of surface finish to lubrication to be sure that refinery procedure will be patterned so as to produce the lubricants which the highly polished parts of precision machinery require for dependable performance.

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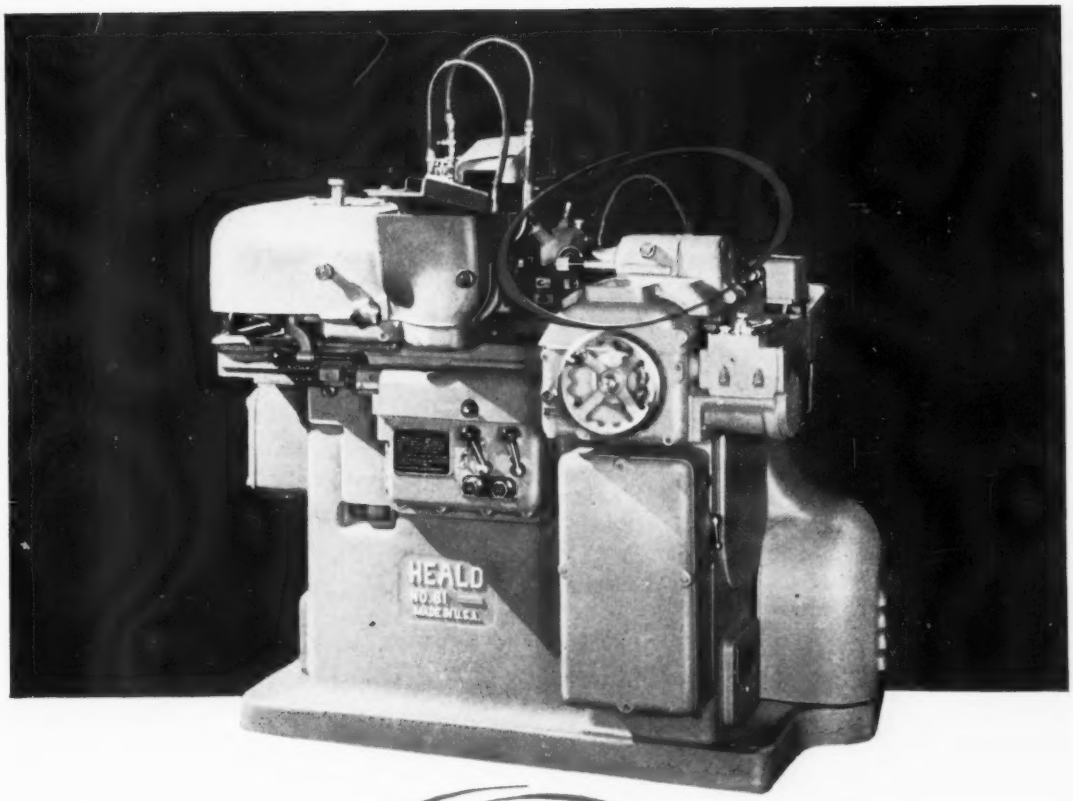

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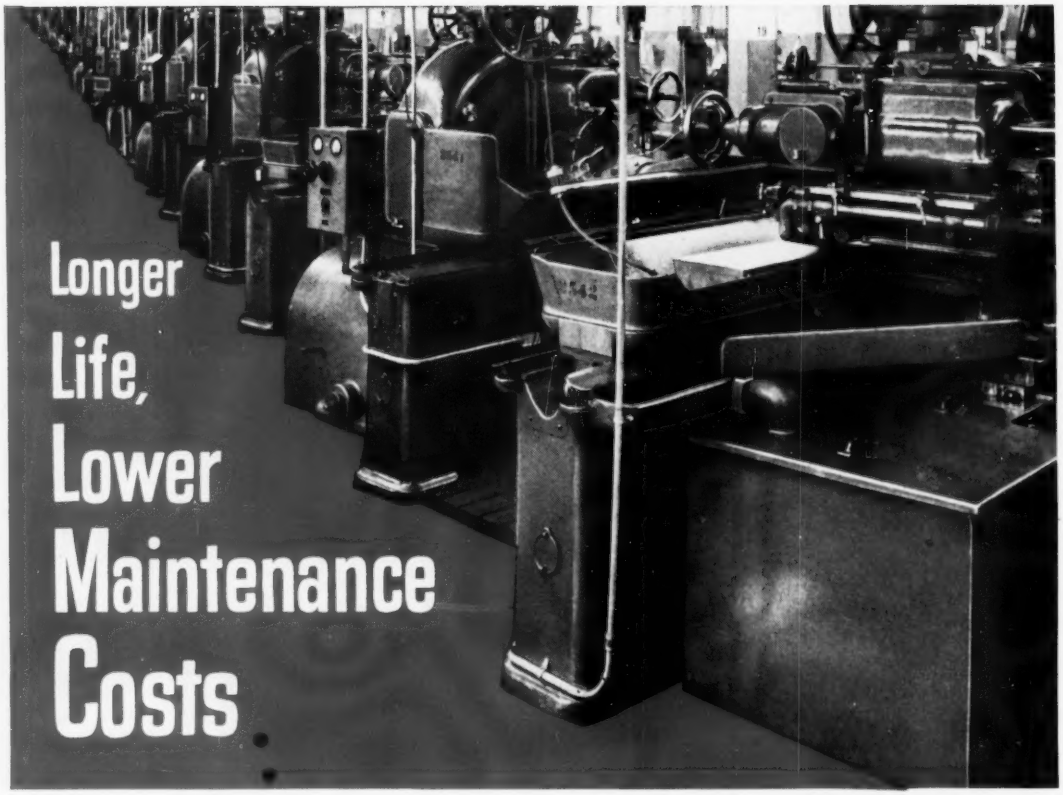

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